

73rd MORSS CD Cover Page

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21-23 June 2005, at US Military Academy, West Point, NY

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Original title on 712 A/B: Marine Corps Bulk Liquid Transportation

Revised title: _____

Presented in (input and Bold one): (WG 19, CG ___, Special Session ___, Poster, Demo, or Tutorial):

This presentation is believed to be:

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Report Documentation Page			Form Approved OMB No. 0704-0188	
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>				
1. REPORT DATE 23 JUN 2005	2. REPORT TYPE N/A	3. DATES COVERED -		
4. TITLE AND SUBTITLE Bulk Liquid Transportation Options Study			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Marine Corps Combat Development Command Studies and Analysis Division 3300 Russell Road Quantico, VA 22134			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited				
13. SUPPLEMENTARY NOTES See also ADM201946, Military Operations Research Society Symposium (73rd) Held in West Point, NY on 21-23 June 2005 . , The original document contains color images.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF: a. REPORT b. ABSTRACT c. THIS PAGE unclassified unclassified unclassified			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 33
19a. NAME OF RESPONSIBLE PERSON				



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Bulk Liquid Transportation Options Study



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Agenda



- **Background**
- **Methodology**
- **Baseline Results**
- **Alternatives**
- **Conclusions**

Agenda



- **Background**
- **Methodology**
- **Baseline Results**
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Background



Study Sponsor

**Brigadier General Robert E.
Schmidle, Jr.**

**Director, Expeditionary Force
Development Center**

Study Team

Team Lead – Captain Jonathan Drexler, USMC

Team Member – Mr. Cortez Stephens

Team Member – Ms. Lori Taylor

Team Member – Ms. Launa Zaffram

Study Objective



Address the Marine Corps capability to provide bulk fuel and water transportation support for (Marine Air Ground Task Force) MAGTF operations:

- Examine the capability of current equipment and processes to transport bulk fuel and water.
- Examine the capability of other equipment and processes, not currently employed by the Marine Corps, to transport bulk fuel and water.

This brief will focus on the fuel transportation piece of the study.

Agenda



- Background
- Methodology
- Baseline Results
- Alternatives
- Conclusions

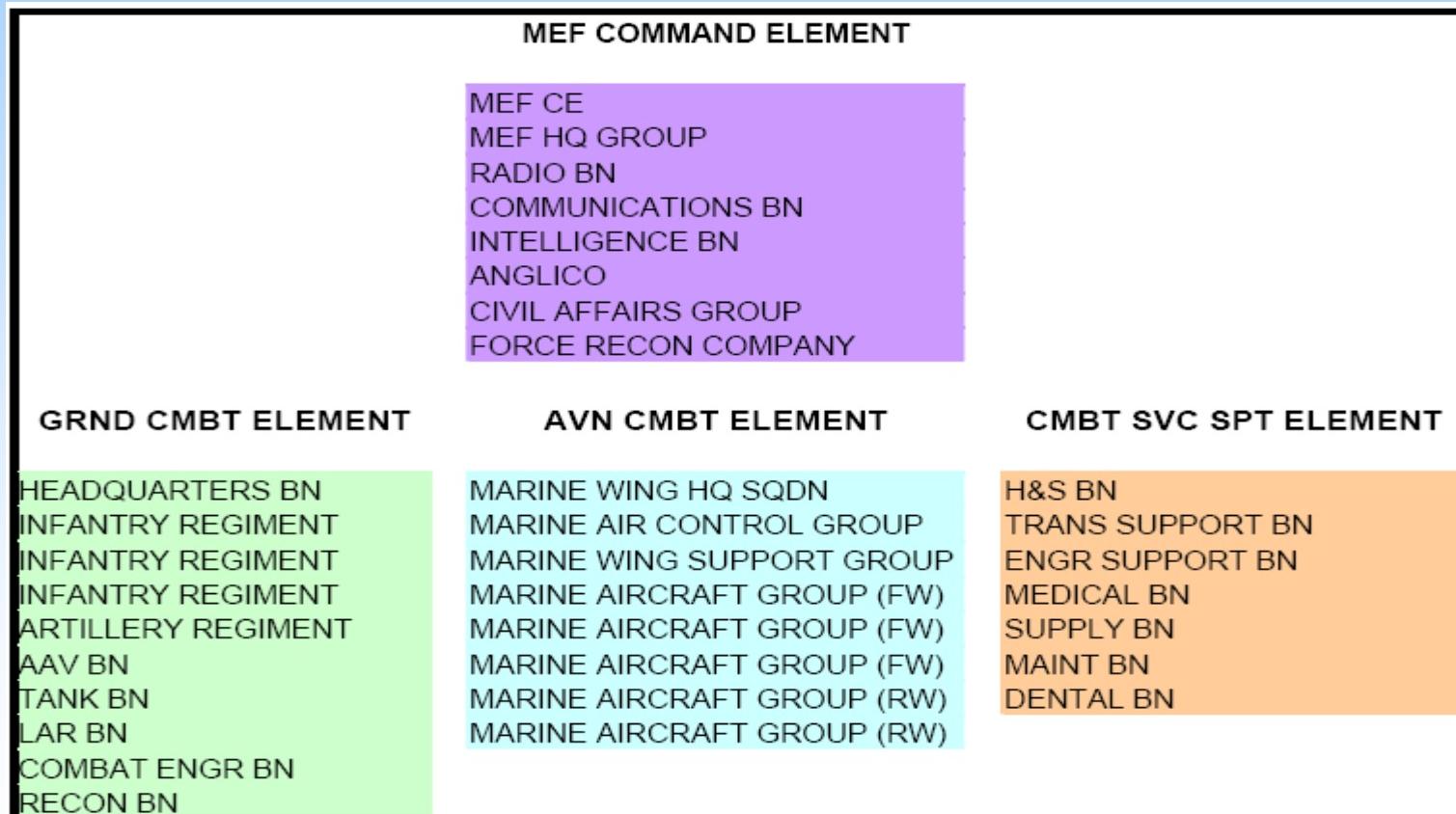


Methodology - Overview

- Notional Marine Expeditionary Force (MEF)
- Mature theater distribution network
- Demand is calculated using Marine Corps planning factors
- Only ground forces and equipment are taken into account
- Network optimization Excel model uses Solver to optimize truck routes among nodes
- Discrete event simulation Extend model builds on results



Methodology – MEF Organization



Methodology – Operational Context

FCSSA – Forward Combat Service Support Area

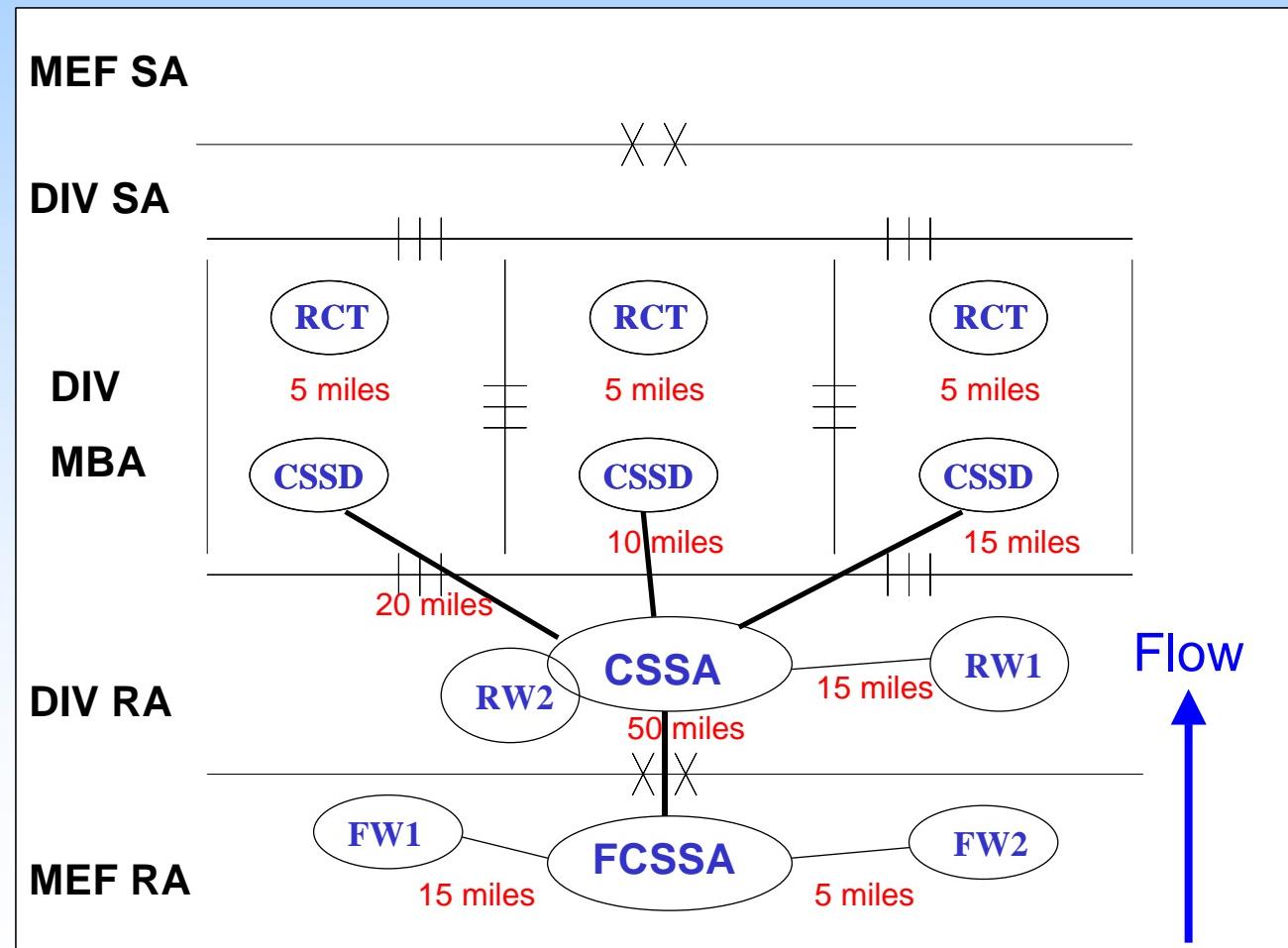
FW – Fixed Wing (Aircraft)

RW – Rotary Wing (Aircraft)

CSSA – Combat Service Support Area

CSSD – Combat Service Support Detachment

RCT – Regimental Combat Team



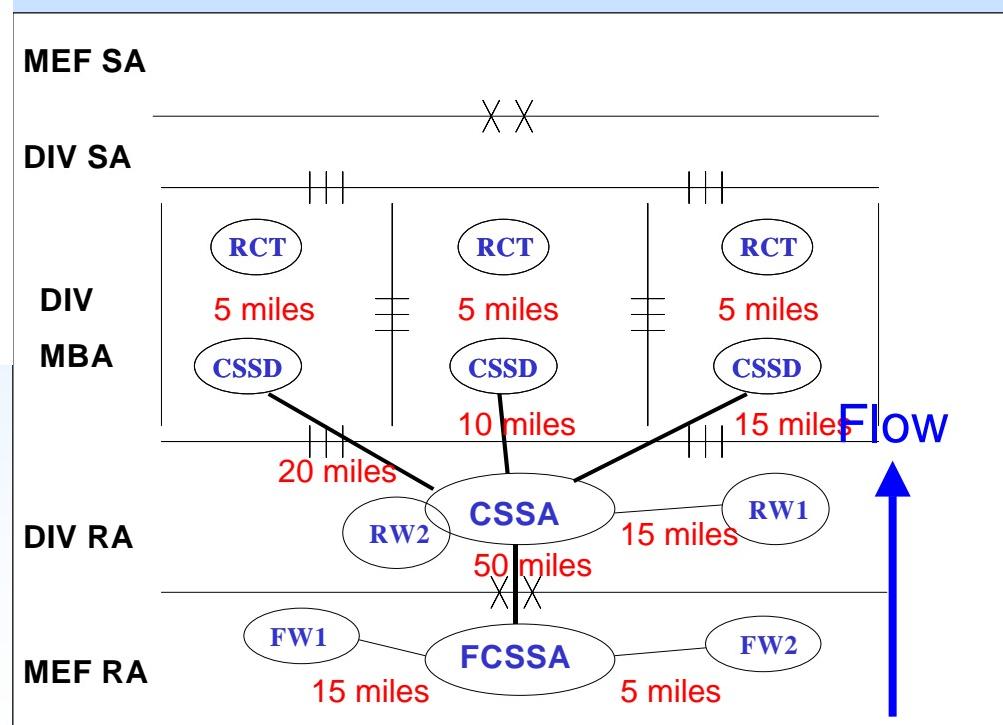


Methodology – Demand

Node	Fuel	Consumption Rate
MEF CP/FCSSA	61,299	Sustained
FW 1	253,121	Sustained
FW 2	159,653	Sustained
RW2/CSSA/DIV CP	357,863	Sustained
RW 1	103,258	Sustained
FARP	15,695	Assault
CSSD 1	19,689	Assault
CSSD 2	19,531	Assault
CSSD 3	19,411	Assault
RCT 1	28,642	Assault
RCT 2	28,695	Assault
RCT 3	28,695	Assault
Total	1,095,552	

Demand is in gallons.

Demand is calculated using Marine Corps planning factors





Methodology – Equipment

- **300** Logistics Vehicle System (LVS)
- **60** Refeulers (20 M970s, 40 Aviation Refueling Capability (ARC) Systems)
- **231** LVS Flatbed Trailers
- **309** Water Trailers (aka: Water Bull)
- **1222** Medium Tactical Vehicle Replacement (MTVR)
- **671** SIXCONs
 - **351** Fuel and **141** Pumps
 - **320** Water and **112** Pumps



Methodology – Excel Model

Network optimization model using Solver

Inputs –

- Equipment Starting Locations
 - Distance Between Nodes
 - Pump Rates
 - % of Equipment Available For Use
 - Truck Speed
 - Truck Running Time
 - Fill Capacity
 - By Percentage
 - By Gallons
 - Truck Fuel Usage



Methodology – Excel Model

Fictional trucks carrying 5,000 gallons are used as placeholders to quantify the known shortfall in organic Marine Corps capability.

Outputs –

- Trucks used along each arc
- Payload used to transport
- Fuel used to transport
- Remaining trucks
- Supply to each node

The trucks used along each arc are then fed into an Extend discrete event simulation model...

Trucks Used	130.0	8.8%
Shortfall Trucks Used	65.0	33.3%
Remaining Trucks	1343.0	91.2%
Fuel Used	8,502	
Payload Available	19,093	
Payload Used	2,978	15.6%

Node	Supply
CSSA 1	642,708
CSSD 1	56,133
CSSD 2	52,245
CSSD 3	53,460
FARP	17,550
RLT 1	28,674
RLT 2	29,160
RLT 3	29,160
Total	909,090

Trucks and Fuel Used	LVS	Tanker	Shortfall	MTVR - Sixcons	MTVR - Drums	ARC	Runs
FCSSA - CSSA 1	19.0	0.0	51.0	0.0	0.0	0.0	1.2
CSSA 1 - FCSSA	44.0	20.0	14.0	0.0	0.0	0.0	1.2
CSSA 1 - CSSD 1	0.0	0.0	0.0	0.0	0.0	0.0	7.7
CSSA 1 - CSSD 2	0.0	0.0	0.0	0.0	0.0	0.0	4.3
CSSA 1 - CSSD 3	0.0	0.0	0.0	0.0	0.0	0.0	5.5
CSSD 1 - CSSA 1	3.0	0.0	0.0	0.0	0.0	0.0	7.7
CSSD 1 - RLT 1	2.0	0.0	0.0	0.0	1.0	0.0	1.8
CSSD 2 - CSSA 1	5.0	0.0	0.0	0.0	0.0	0.0	4.3
CSSD 2 - RLT 2	3.0	0.0	0.0	0.0	0.0	0.0	1.8
CSSD 3 - CSSA 1	4.0	0.0	0.0	0.0	0.0	0.0	5.5
CSSD 3 - RLT 3	4.0	0.0	0.0	0.0	0.0	0.0	1.8
RW Air 1 - FARP	0.0	0.0	0.0	0.0	0.0	3.0	1.3
FARP - RW Air 1	0.0	0.0	0.0	0.0	0.0	0.0	1.3
RLT 1 - CSSD 1	6.0	0.0	0.0	2.0	0.0	0.0	1.8
RLT 2 - CSSD 2	6.0	0.0	0.0	2.0	0.0	0.0	1.8
RLT 3 - CSSD 3	6.0	0.0	0.0	0.0	0.0	0.0	1.8

Methodology – Extend Model

The results of the Excel model are entered in here.

Enter Number of Trucks Here		Enter Demand Here		Enter Storage Here		Enter Starting Amt																																																																																			
FCSSA To CSSA 1 <table border="1"> <thead> <tr> <th></th> <th>Output Time</th> <th>Value</th> <th>Rate</th> <th>Capacity</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>19</td> <td>300</td> <td>2430</td> </tr> <tr> <td>1</td> <td>0</td> <td>51</td> <td>300</td> <td>4500</td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> CSSA 1 To FCSSA <table border="1"> <thead> <tr> <th></th> <th>Output Time</th> <th>Value</th> <th>Rate</th> <th>Capacity</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>44</td> <td>300</td> <td>2430</td> </tr> <tr> <td>1</td> <td>0</td> <td>34</td> <td>300</td> <td>4500</td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> CSSA 1 To CSSD 1 <table border="1"> <thead> <tr> <th></th> <th>Output Time</th> <th>Value</th> <th>Rate</th> <th>Capacity</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> CSSD 1 To CSSA 1 <table border="1"> <thead> <tr> <th></th> <th>Output Time</th> <th>Value</th> <th>Rate</th> <th>Capacity</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>100</td> <td>2430</td> </tr> <tr> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>			Output Time	Value	Rate	Capacity	0	0	19	300	2430	1	0	51	300	4500	2						Output Time	Value	Rate	Capacity	0	0	44	300	2430	1	0	34	300	4500	2						Output Time	Value	Rate	Capacity	0	0	0	0	0	1					2						Output Time	Value	Rate	Capacity	0	0	0	100	2430	1					2					FW1 Demand  262863  157501  357863  CA Demand  19689  M1 Demand  19531  M2 Demand  19411  M3 Demand  103258  RW Demand  15695  F Demand  28642  R1 Demand  28695  R2 Demand  28695  R3 Demand		CA Cap  357863  19689  M1 Cap  19531  M2 Cap  19411  M3 Cap  15695  F Cap  28642  R1 Cap  28695  R2 Cap  28695  R3 Cap		CSSA 1 357863 CSSD 1 19689 CSSD 2 19531 CSSD 3 19411 FARP 15695 RLT A 28642 RLT B 28695 RLT C 28695		FW 1 252863 FW 2 157501 CSSA 1 357863 CSSD 1 19689 CSSD 2 19531 CSSD 3 19411 RW 1 103258 FARP 15695 RLT A 28642 RLT B 28695 RLT C 28695	
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Inputs:

- Trucks along each arc
- Demand at each node
- Storage at each node
- Starting storage amount

Extend model:

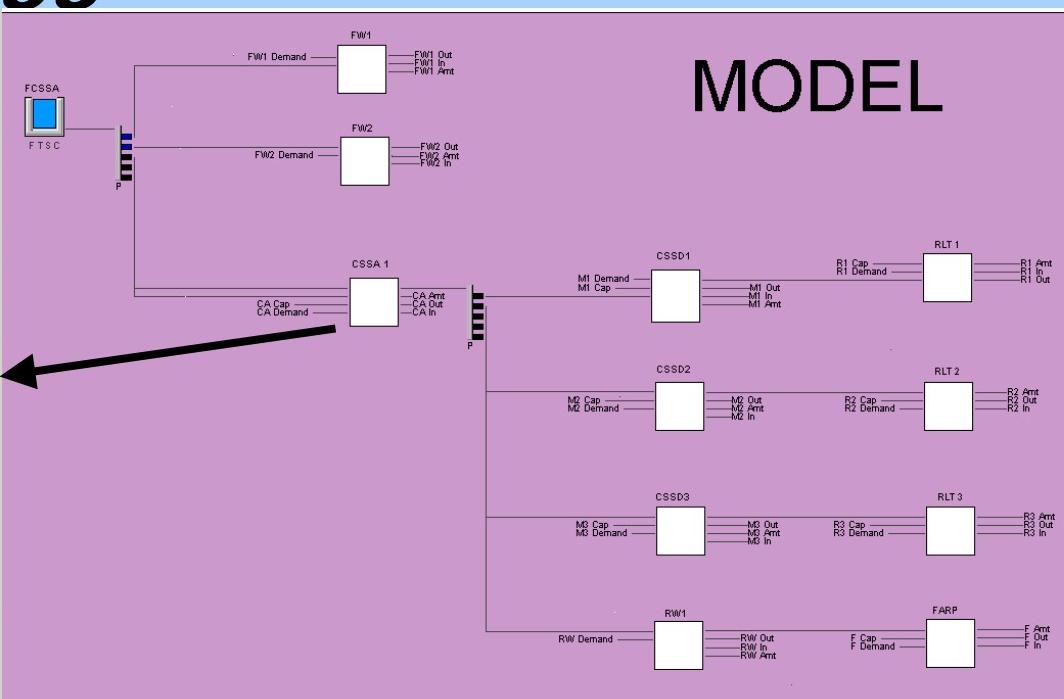
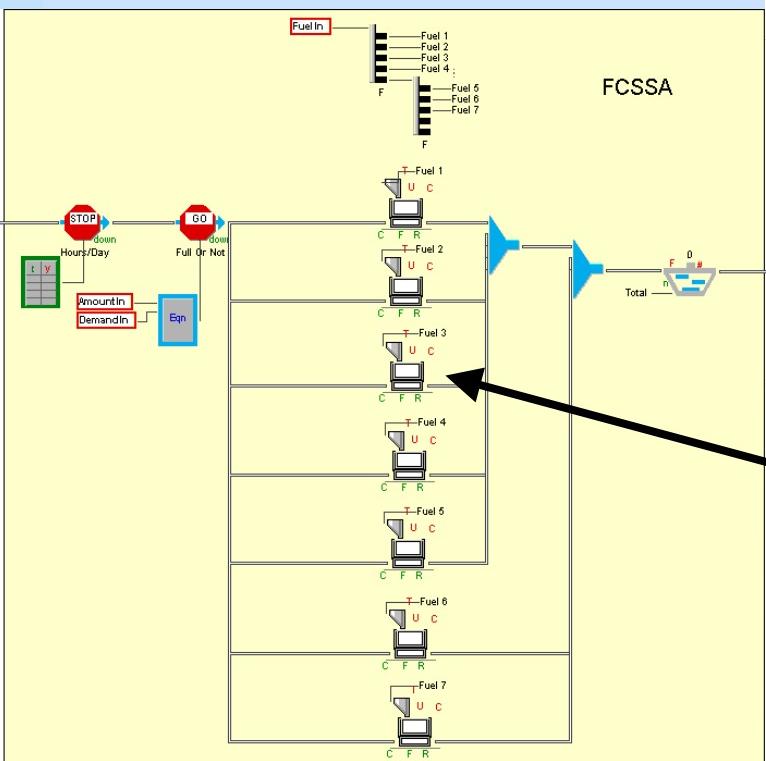
- Discrete event simulation
- Simulation time is 15 days
- Validates the results of the Excel model
- Stochastic variables can be added for sensitivity analysis



Methodology - Extend Model

Extend Distribution →
Network

MODEL



FCSSA Pumps



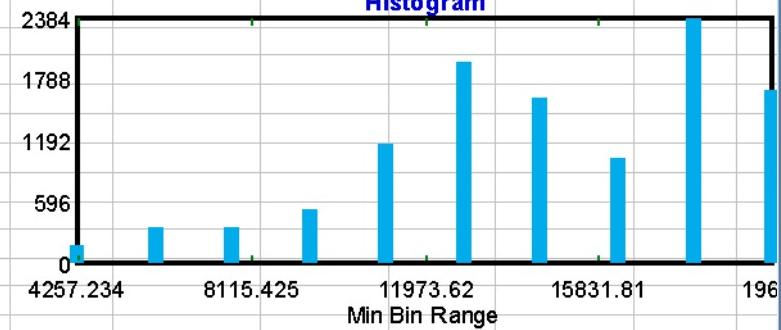
Methodology – Extend Model

Outputs:

Fuel levels
are tracked
at each
node for all
15 days.

CSSD 1		
Total Capacity	19,689	
	Fuel Levels	Instances
At	4,257	180
Between	4,257	352
And	6,186	
Between	6,186	343
And	8,115	
Between	8,115	515
And	10,045	
Between	10,045	1167
And	11,974	
Between	11,974	1967
And	13,903	
Between	13,903	1605
And	15,832	
Between	15,832	1019
And	17,761	
Between	17,761	2383
And	19,690	
At	19,690	1878
	Total	11209

Entries



Fuel levels at CSSD 1

Agenda



- Background
- Methodology
- **Baseline Results**
- Alternatives
- Conclusions



Baseline Results - Overall

- Cannot Deliver Required Amount of Fuel
- Captured the Difference in Terms of “Shortfall Trucks”
- Require an Additional 65 Shortfall Trucks
 - Lack the capability to move 292,500 gallons
- MEF Organic Equipment Cannot Support Fuel Requirements
 - Contract, Army, host nation support?
 - Organic capability?



Baseline Results - Sensitivity Analysis

- How a solution changes with slight changes to the parameters
- Show:
 - Useful information
 - Unknown relationships
- Better understanding of current capabilities

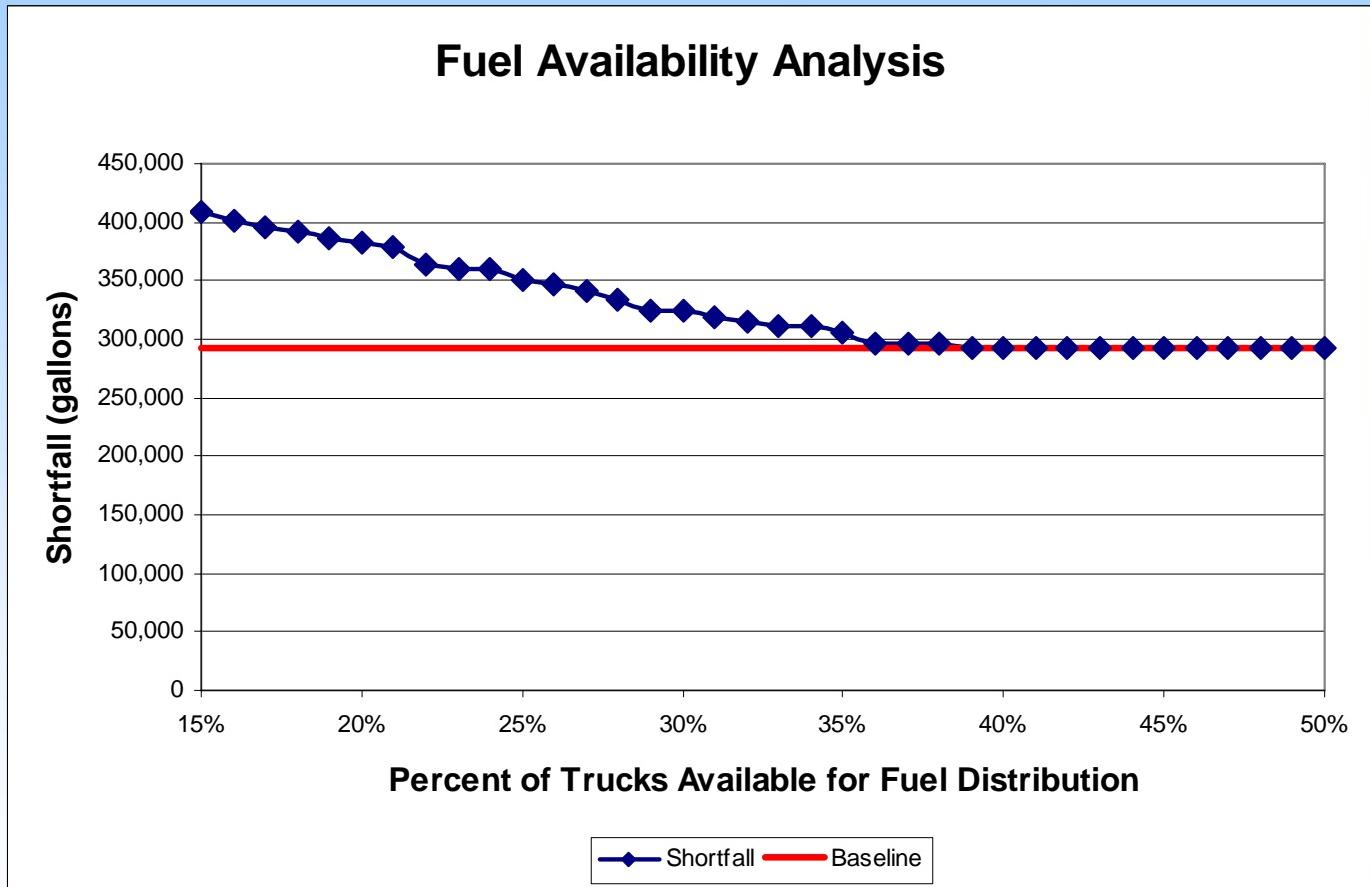


Baseline Results - Sensitivity Analysis

Use of ground assets is allowed up to 35%.

We varied that percentage from 15% – 50%.

The shortage is worsened by a lower percentage, but little is gained by an increase.



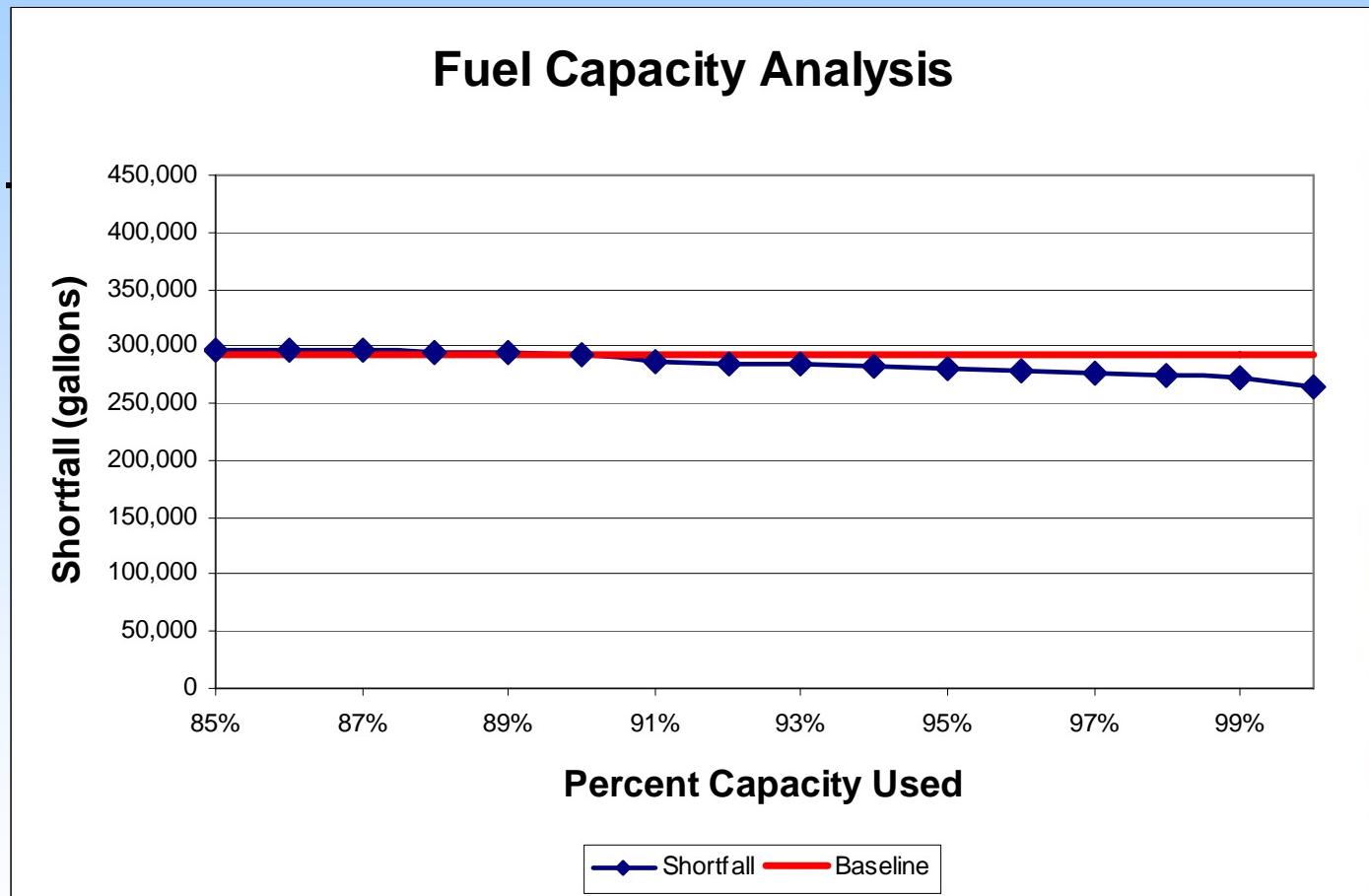


Baseline Results - Sensitivity Analysis

Fill capacity is allowed up to 90%.

We varied that percentage from 85% – 100%.

Little change is observed in shortfall.



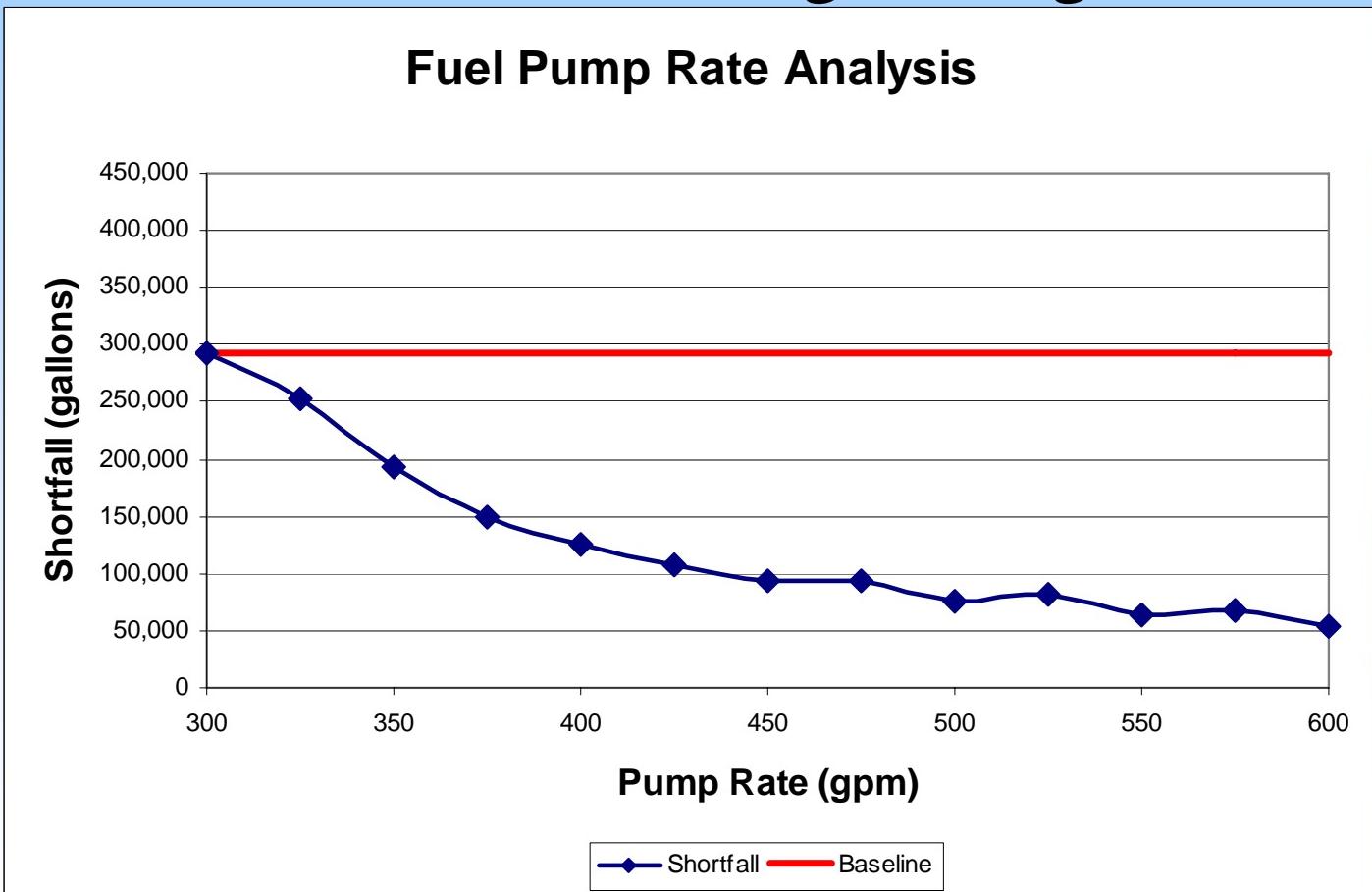


Baseline Results - Sensitivity Analysis

The static pump rate is 300 gpm.

We varied that rate from 300 – 600 gpm.

There appear to be significant gains in small increases in pump rate.



Agenda



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Alternatives

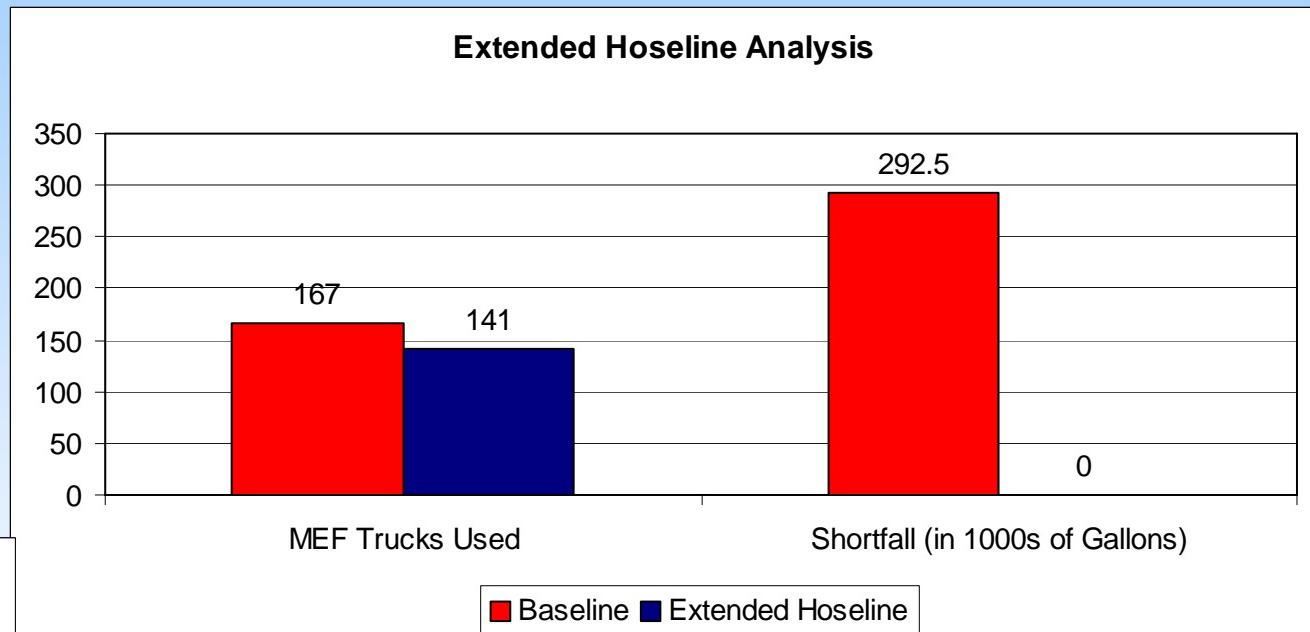
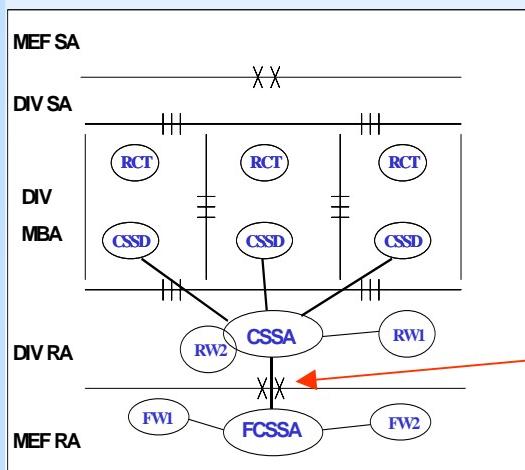
- **Three Alternatives:**
 1. Extended Hoseline
 2. Logistics Vehicle System Replacement (LVSR) and Flatrack Refueling Capability (FRC).
 3. LVSR, FRC and Expeditionary Fueling System (EFS).
- **Each Compared Separately to Baseline Results**



Alternatives - Extended Hoseline

Changes:

- 50 miles of additional hoseline
- From FCSSA to CSSA
- Capacity: 425,000 gallons/day



Hoseline

Conclusions:

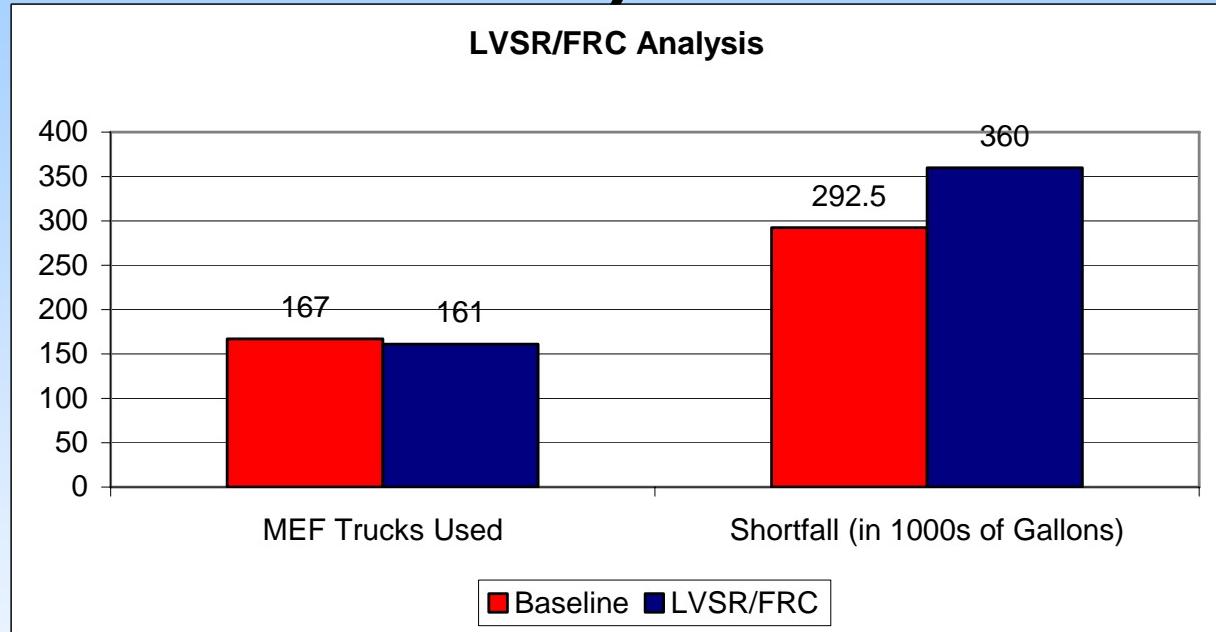
- Hoseline may not always be possible.
- Whenever possible, it can be very effective.



Alternatives - LVSR/FRC

Changes:

- Replace LVS with LVSR
 - 300 LVS → 263 LVSR
- Replace M970 with FRC
 - 20 M970s → 40 FRCs
 - 2,750 gallon Capacity



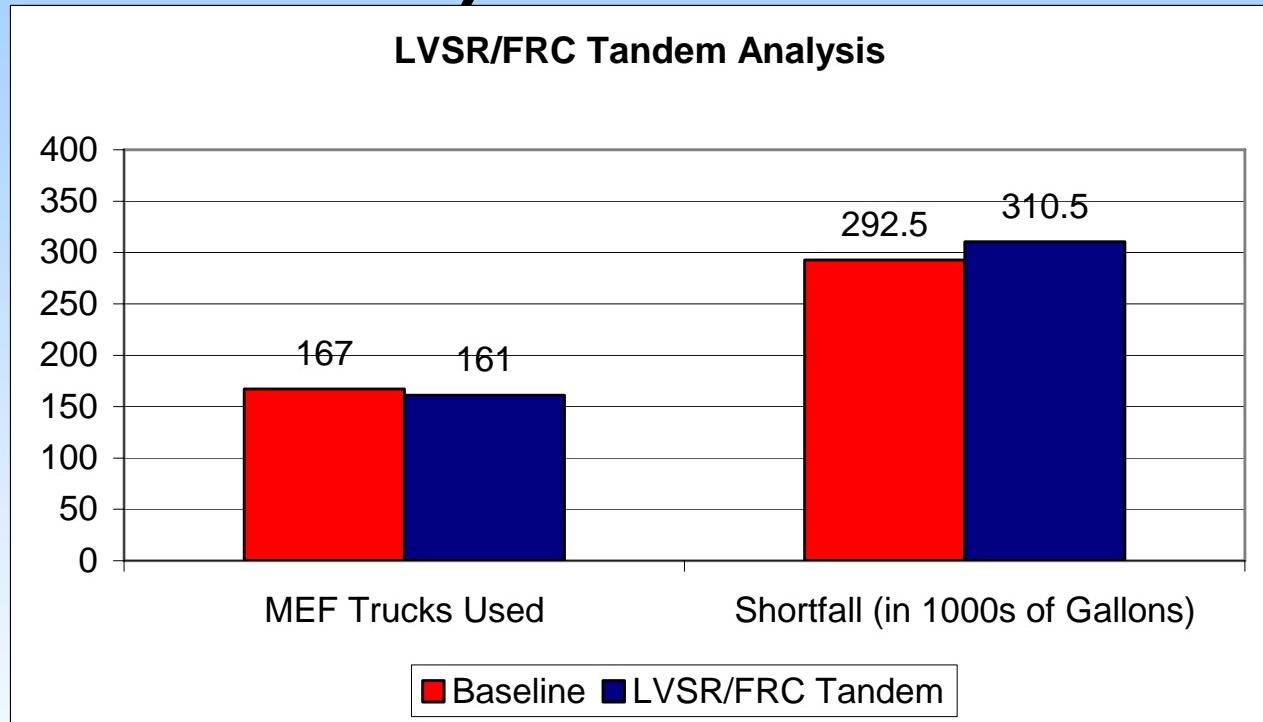
Conclusions:

- Fewer LVSRs as compared to LVS
- SIXCONs and FRC now compete for trailer space
 - No longer a dedicated fuel truck

Alternatives - LVSR/FRC Tandem

Changes:

- 45 tandem trailers
 - FCSSA: 15
 - CSSA: 30
- Capability to move twice the fuel
- Engineering issues not taken into account



Conclusions:

- Fewer LVSRs as compared to LVS
- SIXCONs and FRC now compete for trailer space
 - No longer a dedicated fuel truck
- Tandem trailers may help alleviate some shortfall



Alternatives – LVSR/FRC/EFS

Expeditionary Fuel System (EFS):

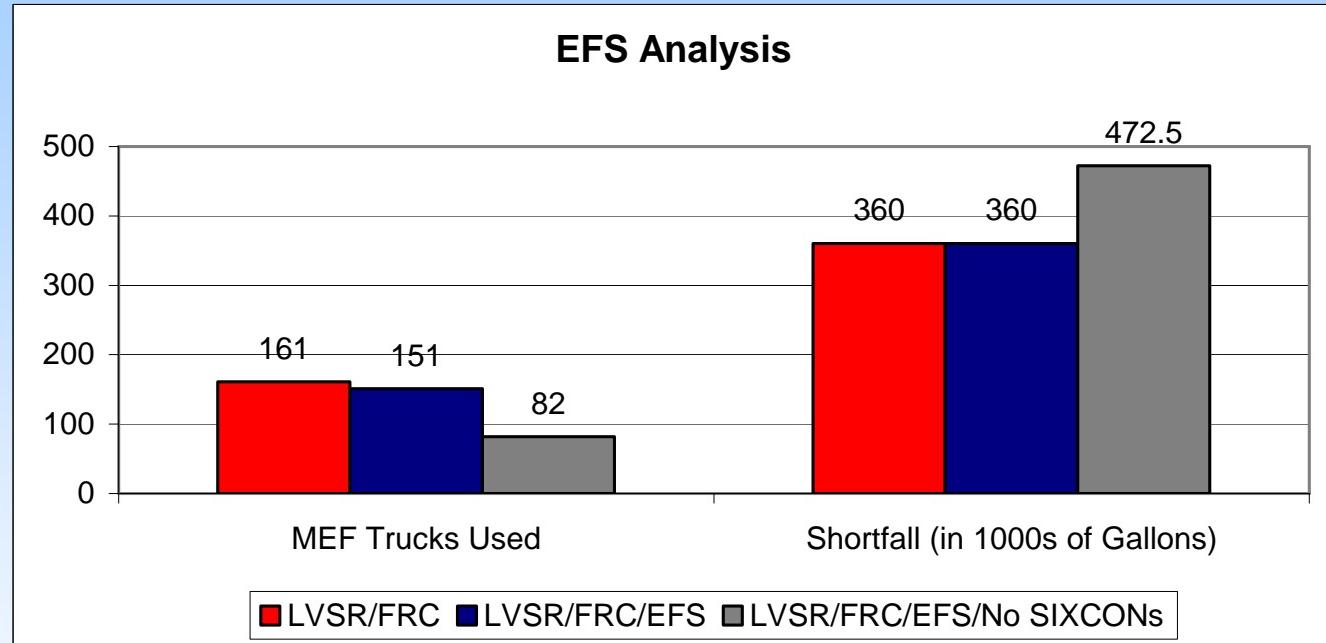
- Modular petroleum distribution system capable of being manhandled, self-pumping, refueling both ground vehicles and aircraft
- Consist of two variations (ORD)
 - Small: 20 – 50 gallons
 - Medium: 150 – 300 gallons
- Multiple, lightweight, collapsible tanks

Version	Small	Medium
Capacity (gal)	28	300
Full Weight	239	2245
Empty Weight	43	145
Length (inches)	47	85
Width (inches)	16	36
Height (inches)	16	36
Stacking Limit	4	2

Alternatives – LVSR/FRC/EFS

Change:

- Add EFS
 - 54 Small: 28 gallons
 - 54 Medium: 300 gallons
- Macro level – not adding a significant capability
- Comparison: No SIXCONs



Conclusion:

- As fielded, the EFS doesn't make a significant difference
- The removal of SIXCONs significantly complicates the situation
 - SIXCONs are an essential part of Bulk Fuel Transportation

Agenda



- **Background**
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Conclusions

- Shortfall in transporting bulk fuel is 292,500 gallons per day
- Three ways to address the shortfall in the MEF's current capability:
 - Non-Marine Corps support - host nation or the U.S. Army
 - Obtain additional multi-use systems - LVS/SIXCON combination
 - Obtain single-use systems - ARC or the D1134 Tractor/M970 refueler combination
- Pump rates can have a significant effect on the results
- Extending the battlespace dramatically increases the shortfall
- When possible, extended hoseline can be very effective in reducing the fuel shortfall
- SIXCONs are an integral part of fuel distribution and are the limiting factor in the MEF's ability to satisfy its fuel requirements
- The FRC competes with SIXCONs for space on the LVSR and does not necessarily give the Marine Corps a greater capability
- The EFS shows some benefit when added to current equipment and processes

Questions?

